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EDITORIAL COMMENT

Man Must Measure

Except for Cardiologists!*

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When Lancelot Hogben (British mathematician, zoologist, and humanist, 1895 to 1975) said "Man Must Measure" (1) he had obviously not met a cardiologist! Cardiologists interpret images from various modalities: ultrasound, nuclear medicine, cardiac magnetic resonance (CMR), computed tomography, and invasive angiography. Although there are a vast number of published reports indicating

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that quantification of images improves accuracy and decreases observer error compared with visual interpretation alone (2–4), cardiologists ignore this evidence. Any measurements that are routinely made and reported are performed either by technicians (as in the case of ultrasound) or by automated programs (as in the case of nuclear medicine). In areas where technicians and automated methods are not employed for quantification (such as the cardiac catheterization laboratory), eye-balling is the norm, even when clinically important decisions need to be made—such as implanting a stent in a coronary artery. Surprisingly, even clinical trials have succumbed to this penchant for refusing to measure: one can now place an expensive implantable cardioverter defibrillator simply by visually estimating an ejection fraction from an echocardiogram (5), where in many instances the entire endocardium is not even visible unless contrast is used.

Why is this so? In the old days, lack of digital images and measurement programs was the main excuse. Now the common excuse is lack of time in a busy clinical practice. Some have even gone so far as asserting that their "eye balling" is as accurate as any measurement and so they do not need to stoop so low as to actually make one (6)! I believe that the main reason is that payers do not demand it. If payers only reimbursed us for imaging tests if reporting cardiologists had themselves made the measurements, we would all soon be pretty facile at using all the quantification programs that are readily available to us. We would then be more careful and hence more accurate. Something, we all would agree, that our patients deserve.

One of the most elusive measurements in coronary artery disease patients has been that of myocardial blood flow (MBF). Single-photon emission computed tomography can measure myocardial tracer uptake that reflects relative myocardial blood volume and not relative blood flow (7). Positron emission tomography (PET) is limited to sites that possess generators or cyclotrons. Myocardial contrast echocardiography has poor clinical penetration. Computed tomography requires very large doses of radio-opaque dyes to measure myocardial perfusion that can cause renal injury. Gadolinium–diethylenetriamine pentaacetic acid can be safely used as a CMR myocardial contrast agent in patients with adequate renal function and has become popular for assessing myocardial viability. However, it is not routinely used for MBF measurement, despite its ability to do so (8).

What then is the relevance of the report by Christian et al. (9) in this issue of *iJACC*? Although the main purpose of the investigation was to compare a 3.0-T with a 1.5-T magnet, they once again showed the feasibility of CMR for quantification of resting MBF and coronary flow reserve (CFR). There are a vast number of published reports on the clinical and physiological importance of CFR. Its initial clinical application was for determining the

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physiological significance of coronary stenosis (10). Since then, it has been demonstrated that the most important determinant of CFR is capillary resistance (11), and any condition where capillary number or dimension is reduced results in a decreased CFR (12). Similarly, if capillary resistance is elevated by a high blood viscosity via an increase in hematocrit or a decrease in erythrocyte negative charge, deformability, or mobility, CFR will decrease (13). Thus, myocardial infarction (14), hypertension (15), nonischemic dilated cardiomyopathy (12), and hyperlipidemia (16) are all associated with reduced CFR, which has important prognostic implications.

Christian et al. (9) show that CMR can be used to quantify MBF and CFR in an animal model. If one assumes that it can also be used to measure MBF and CFR noninvasively and reliably in humans, will this approach be used clinically, given the propensity of cardiologists to shy away from making measurements? After all, the availability of CMR or image quality is not in question. Simply on the basis of previous experience, the answer is "No." For instance, it has been demonstrated that patient outcome is better when coronary stent placement is guided by fractional flow reserve rather than angiography (17). However, this measurement is not routinely performed before coronary stent placement. Neither is intravascular ultrasound routinely used to determine the success of stent deployment despite data to support its use for this purpose (18). If reimbursement for stent placement was based on performing these tests then they would be performed. As a consequence, fewer stents would be placed, and they would be better deployed, decreasing cost and potentially improving outcome.

This is a sad commentary on our *modus operandi*. We have such powerful imaging tools at our disposal now that provide us with unbelievably detailed anatomical and physiological information, which would not have seemed possible even a couple of decades ago. In the context of coronary artery disease, it should be a cause of excitement and celebration that we can now quantify MBF and CFR noninvasively. But we don't seem to care. We refuse to make measurements that could further refine our approach to patient care. This disparity between what we can do and what we actually do widens year by year. It is not that introducing new technologies and discoveries to cardiologists is like casting pearls before swine. We are not stupid, but too many of us seem to be comfortable with mediocrity and the *status quo*. We seem also to not be very interested in precision, especially if we have to make the measurement ourselves! The conclusion seems to be that we only do things that we have to, not what we ought to.

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